M47/TU FUEL SYSTEM:

Situation.

With the increase of Diesel engines in our market and an increase in repair costs, it has been illustrated that a diagnosis aid for common rail diesel engines is required, this was mentioned at the Technical Forum in March 2003. This guide should be printed then issued to all technicians working on Diesel engines. The guide is not intended as a replacement for DDE training courses at the CFD.

This document has been produced as an addition to the "M57 poor performance/Lack of power guide". The M47/tu has the second generation of common rail fuel system, the operation and diagnosis techniques of the fuel system are described here. The M57 guide should be studied first, refer to GB11-001-03 for back ground information.

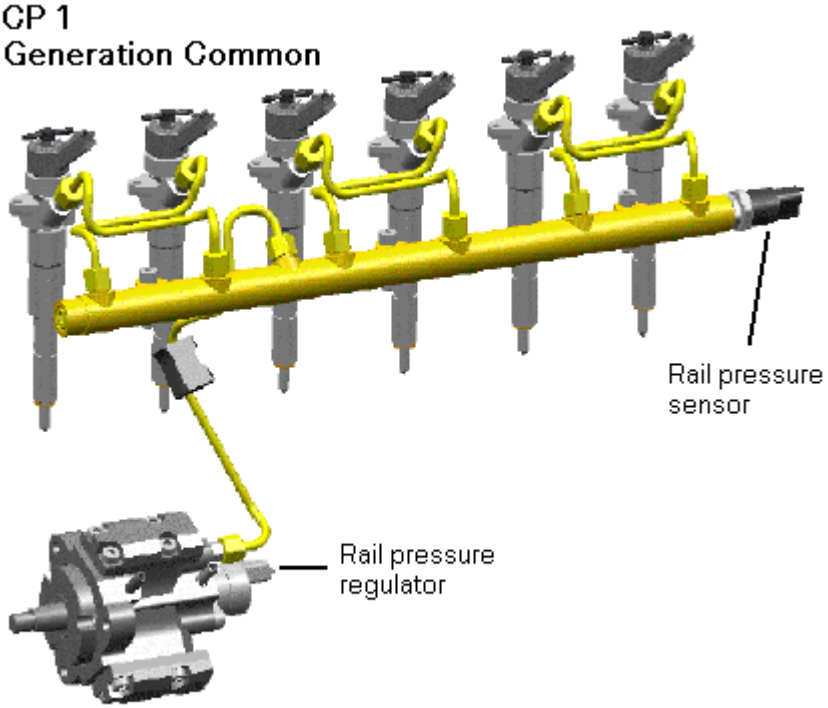
M47/TU Production History:

M47/tu	= E46 320d Comp	From 09/01
	= E46 320d saloon	From 09/01

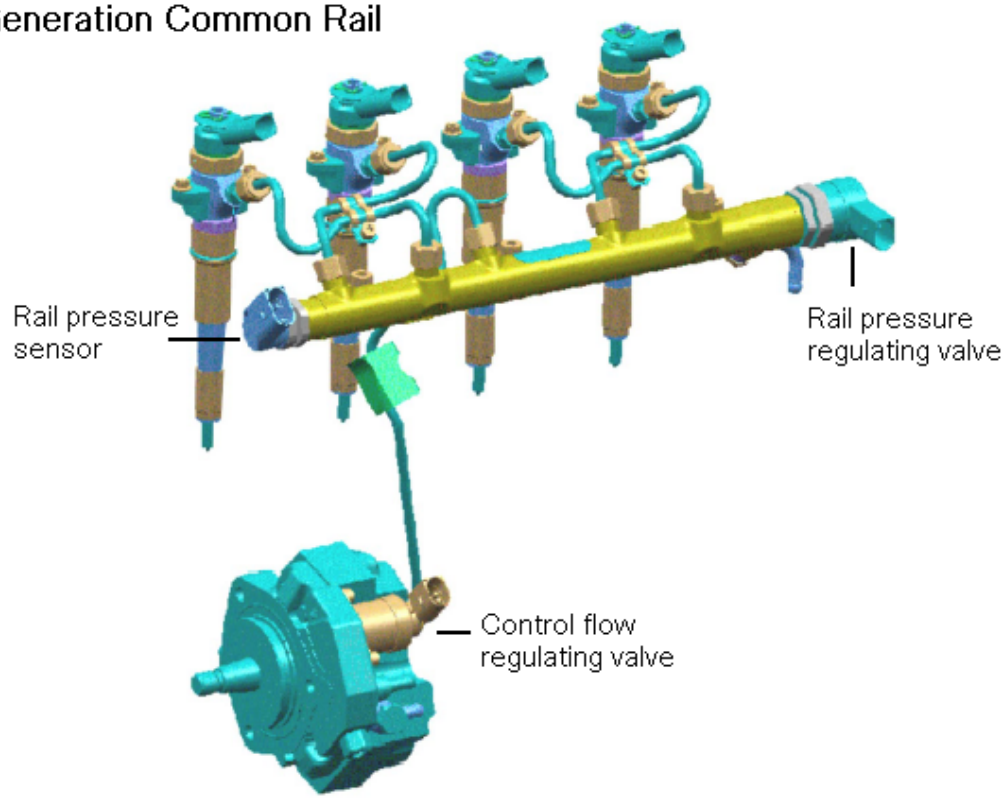
Functional Description: CP3.2 (second generation common rail)

In the **first-generation common-rail** system the M57 rail pressure is controlled by a pressure control valve at the HPP (High pressure pump). The HPP therefore always delivers fuel at the maximum rate and a lot of heat is generated. The pressure-regulating valve builds the pressure in the rail and dumps the excess pressure into the fuel return line. Fuel pressure is varied between 350-1350 bar by this valve. This means that a heat exchanger / fuel cooler has to be installed in the fuel circuit. A disadvantage of this system is increased fuel consumption due to heated fuel and unnecessary work from the HPP.

M57 CP 1
First Generation Common Rail



M47/TU CP3.2 Second Generation Common Rail



In addition to the fuel circuit of the M57 the M47/tu with second generation Common Rail has a control flow-regulating valve installed.

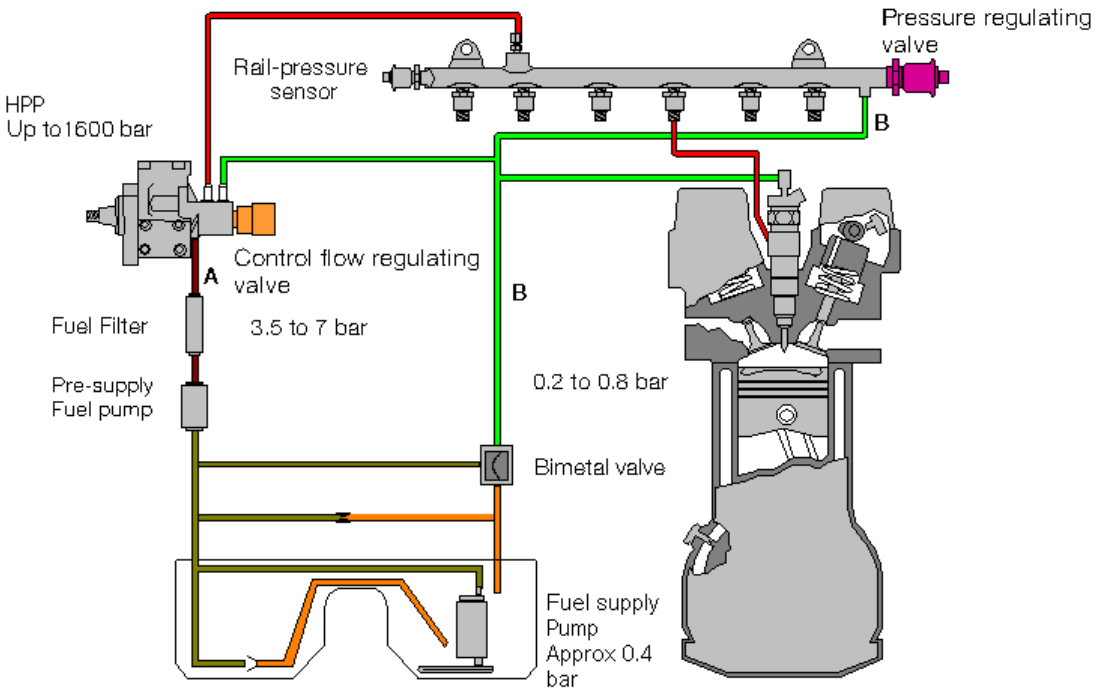
In the **second-generation common-rail** system the control flow regulating valve controls the pump delivery rate in such a way that only the volume of fuel actually required (dependant on engine speed and load) is supplied to the CP 3.2 HPP.

The more that this control flow regulating valve is activated by the DDE the more that the fuel supply is restricted to the HPP.
If the control flow-regulating valve is disconnected the DDE will operate the fuel system using just the rail pressure-regulating valve, the operation will then be the same as the M57.
The control flow-regulating valve is not used below 19 degrees C coolant temperature to improve running characteristics.

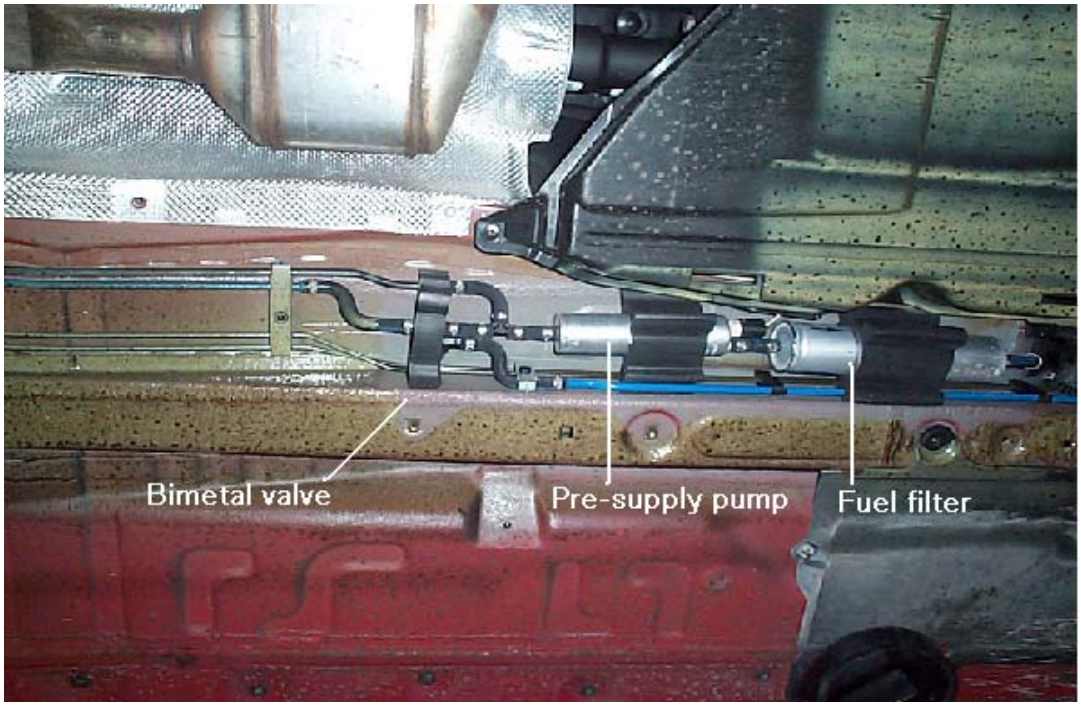
The pressure-regulating valve is pulse width modulated by the DDE, the more that it is activated the higher the increase in the rail pressure.
If this component is disconnected, no rail pressure is built up and the engine will stall and not start.
The HPP can produce over 450 bar @ 250rpm and can produce up to 1600 bar when required, typically at high engine speed and under load.
This engines speed is limited to 4000rpm when the vehicle is stationary.

The function of the second-generation common-rail fuel system is the same on the M47/tu engine and that of the M57/tu engine (6 cylinder engine in the E60 and E65)**, however the pre-supply fuel system differs between engines and between the E60 / E65.**

1. **M47/tu Pre-supply Fuel:**



Pre-supply component location: (n/s undertray / trims removed)



When trouble shooting the fuel system ensure that there is at least ¼ tank of fuel on board.
The fuel pre-supply and return pressure must be checked as this is of vital importance with regards to correct fuel injection.

The pre-supply pressure should be checked with a mechanical gauge as there is no pre-supply pressure sensor on this engine. This should be 3.5 – 7 bar at points marked "**A**". (In fuel schematic)
The fuel return pressure should be 0.2 – 0.8 bar at points marked "**B**".

If there are faults that are only induced into the DDE or a noticeable lack of power when the engine is under load you must road test with a mechanical fuel gauge plumbed into the pre-supply circuit to ensure that the pressure is not dropping off when the HPP is using a lot of fuel.
Blocked fuel filters have been a problem on the M47/tu, please refer to Technical Bulletin 16-001-02 for typical fault codes that can be stored as a result.
The fuel filter should be replaced first in the event of rail pressure faults. During replacement the fuel escaping should be examined for swarf. Refer to GB 16-001-03 if any debries have been found on inspection.

The correct fuel transfer to the right hand side of the tank should also be checked, this should be carried out to ensure that the lift pump has sufficient fuel. Conduct this using test step 6.0 of the cluster test functions; refer to

the Functional description on the Instrument cluster for access to these test functions.

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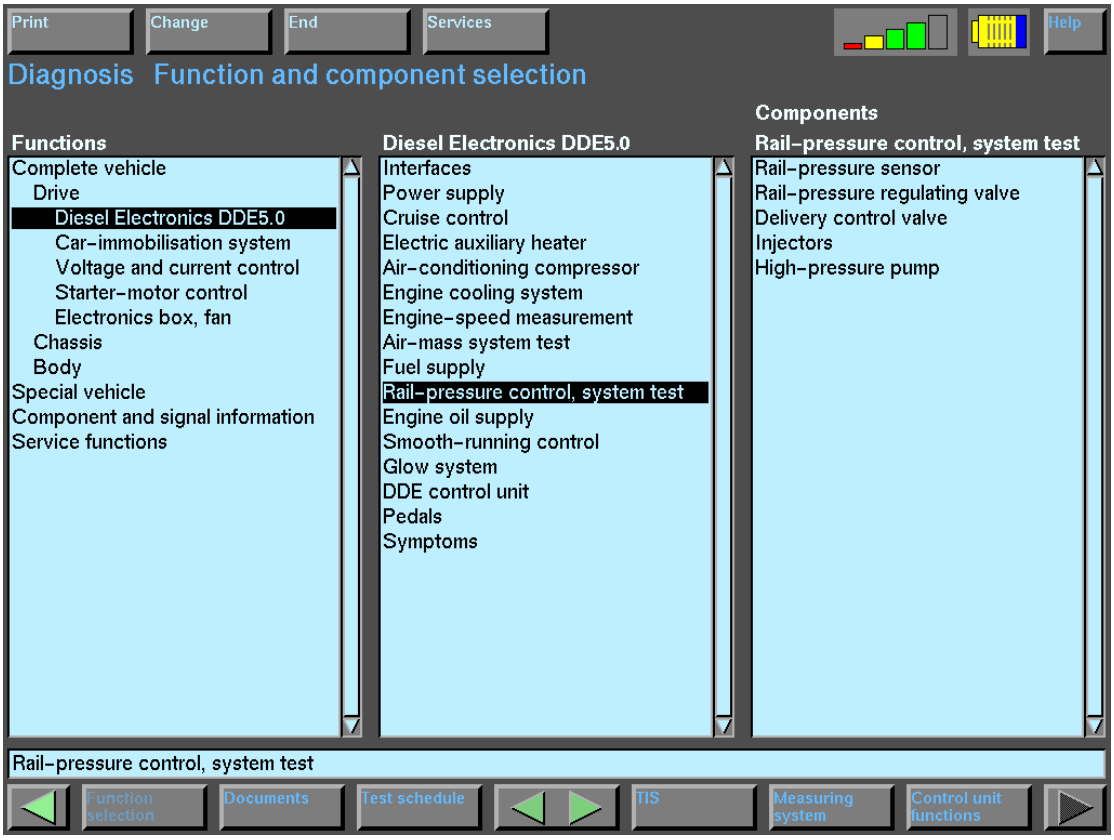
2. M47/tu Rail Pressure:

If there are faults with the fuel rail pressure then the rail pressure system test must be conducted. When this is conducted using the Dis+ a comprehensive test on all components is performed.
The components can be tested individually but to use the whole test select "Test schedule" before highlighting a component. (See below)



Explanation of the Rail-Pressure System Test:
The test schedule is laid out as follows:

Is the tank empty or was it driven empty?
You should also consider Technical Bulletin GB 13-001-03 (the vehicle may have of been incorrectly fuelled)

YES

Fill fuel tank and bleed the fuel system using the DDE service functions.
Due to the increased pressure in the second-generation system an air free fuel system is paramount

NO

Is the pre-supply pressure upstream of the HPP OK?
You are advised to check this using the repair instructions 13 31 028 refer to the fuel schematic on page 3 for the correct fuel pressures at different points in the circuit.

NO

Check the operation and replace as necessary the fuel filter, fuel pre-supply pump, fuel lift pump, damaged lines, Bimetal valve.
Blocked fuel filters have been a problem on the M47/tu, please refer to Technical Bulletin 16-001-02

YES

Check the high-pressure system for external leaks.
Is the high-pressure system leak-tight?

NO

Check the system for leaks.
If the HPP was leaking from the front seal you would find Diesel in the oil sump. Carry out a quick oil level check.

YES

In the next step, the rail pressure is checked with the ignition ON.
Turn off the engine.
Turn ignition lock to position 2.
Note: The rail pressure drops only slowly after turning off the engine. Wait until the rail pressure drops no further.

Compare setpoint and actual value.
Setpoint:
Rail pressure = 0 +/- 13 bar

Was the setpoint reached?

NO

If the rail pressure sensor is providing a reading that is not in specification then the sensor could be at fault. The connection and wiring should also be checked.

When testing the HPP with special tool 13 5 450 the rail pressure sensor and pressure-regulating valve are substituted. This test will help eliminate a fault with the rail pressure sensor. You can fit this tool and then check the reading from this sensor from status requests. The use of this tool is illustrated further on in this guide.

YES

Can the engine be started?

NO

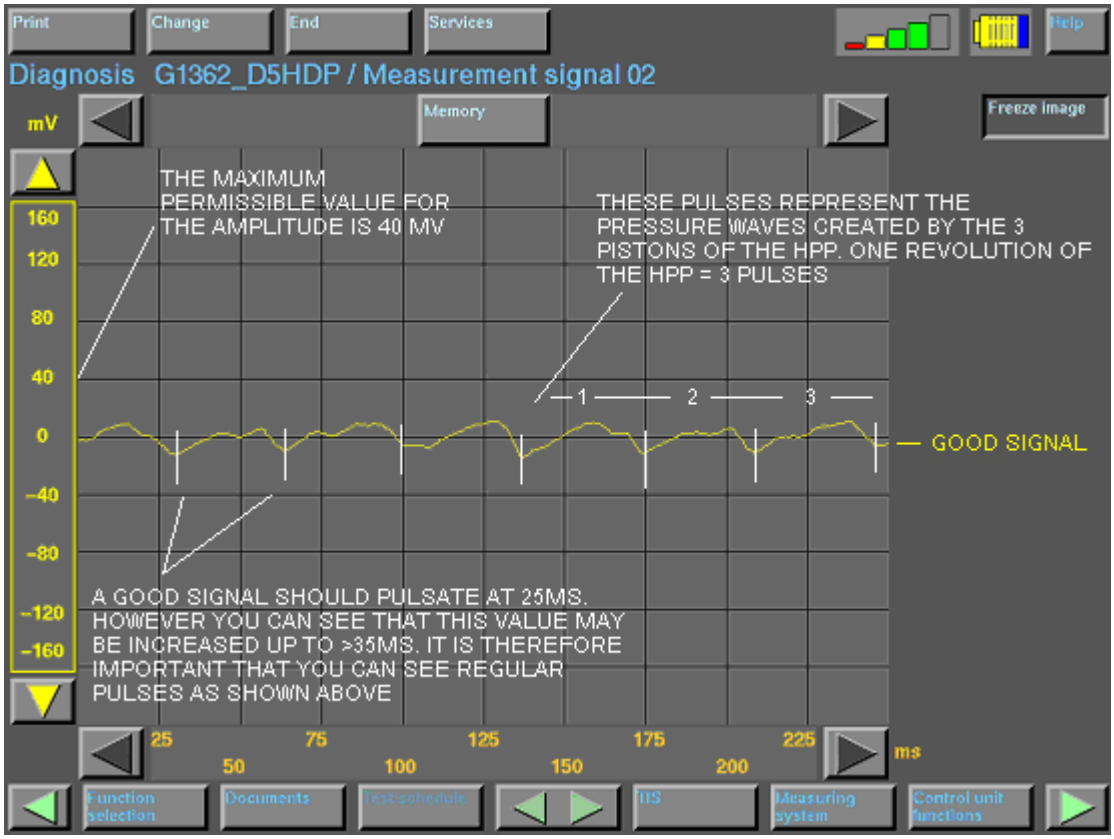
If the engine cannot be started refer to **2B** further on, the rail pressure system test splits at this point

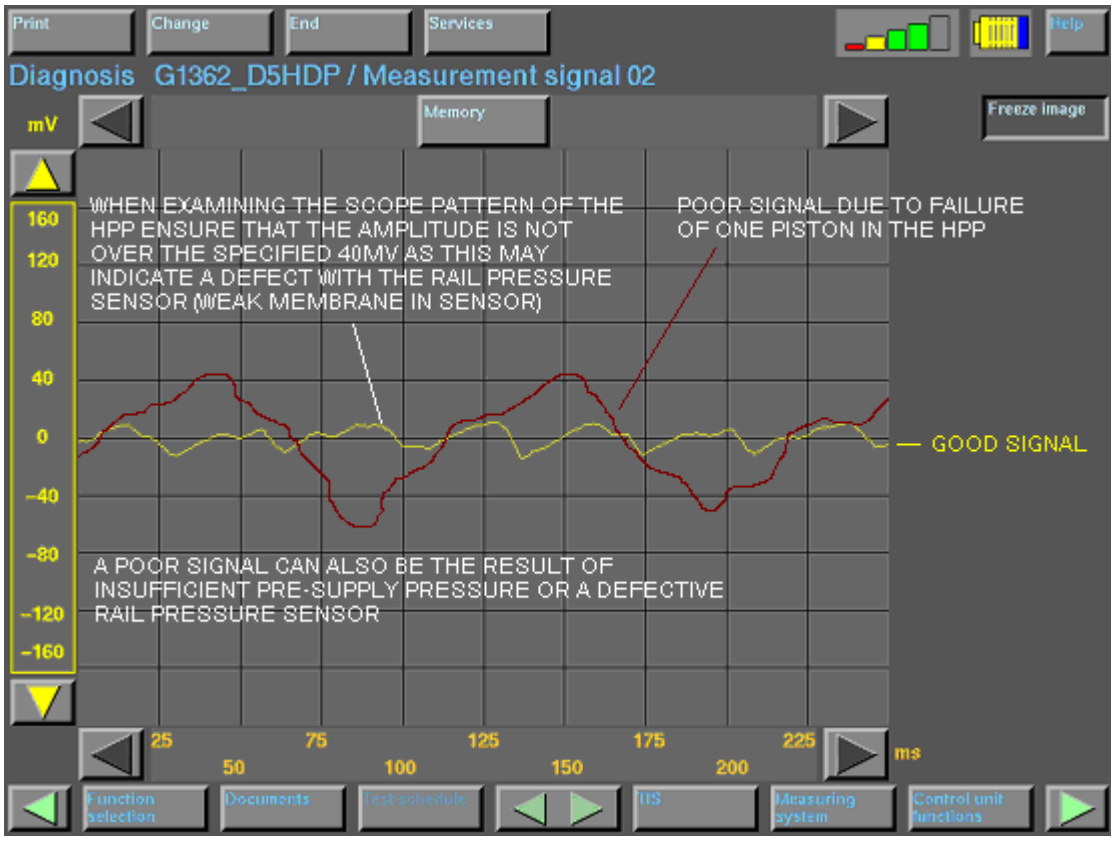
YES

2A

In the next part of the test schedule the HPP is tested.
The oscilloscope is used during the test schedule to monitor the 3 pressure waves from the 3 pistons of the high-pressure pump into the common rail via the signal line from the rail pressure sensor. You will be guided through the connections for the measurement using the DIS.
There are preconditions for this test:
Fuel level sufficient (reserve lamp off)
Common rail system free of leaks.
No fault codes stored.

Scope the HPP as instructed.


Print
Change
End
Services
Help
Diagnosis G1362_D5HDP / Measurement signal 02
mV
Memory
Freeze image
THE MAXIMUM PERMISSIBLE VALUE FOR THE AMPLITUDE IS 40 MV
THESE PULSES REPRESENT THE PRESSURE WAVES CREATED BY THE 3 PISTONS OF THE HPP. ONE REVOLUTION OF THE HPP = 3 PULSES
160
120
80
40
0
-40
-80
-120
-160
1
2
3
GOOD SIGNAL
A GOOD SIGNAL SHOULD PULSATE AT 25MS. HOWEVER YOU CAN SEE THAT THIS VALUE MAY BE INCREASED UP TO >35MS. IT IS THEREFORE IMPORTANT THAT YOU CAN SEE REGULAR PULSES AS SHOWN ABOVE
25
50
75
100
125
150
175
200
225
ms
Function selection
Documents
Test schedule
TIS
Measuring system
Control unit functions


Print
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Diagnosis G1362_D5HDP / Measurement signal 02
mV
Memory
Freeze image
WHEN EXAMINING THE SCOPE PATTERN OF THE HPP ENSURE THAT THE AMPLITUDE IS NOT OVER THE SPECIFIED 40MV AS THIS MAY INDICATE A DEFECT WITH THE RAIL PRESSURE SENSOR (WEAK MEMBRANE IN SENSOR)
POOR SIGNAL DUE TO FAILURE OF ONE PISTON IN THE HPP
160
120
80
40
0
-40
-80
-120
-160
GOOD SIGNAL
A POOR SIGNAL CAN ALSO BE THE RESULT OF INSUFFICIENT PRE-SUPPLY PRESSURE OR A DEFECTIVE RAIL PRESSURE SENSOR
25
50
75
100
125
150
175
200
225
ms
Function selection
Documents
Test schedule
TIS
Measuring system
Control unit functions

Does the displayed signal progression correspond to the good signal above?

Note:
Fault code 42E2 (change over, rail-pressure control) is stored as a result of this test, this is because the control flow valve is taken out of operation. The system then operates without control flow regulation i.e. without operation of the control flow-regulating valve. The difference in operation is explained in the functional description on page 3. The fault should be deleted from the fault memory on completion of diagnosis.

NO

Replace the HPP.
If a defect is found with the HPP and it needs to be replaced check the fuel system for contamination by metal swarf and refer to Technical Bulletin GB-13-001-03 for the necessary repair.
It is **paramount** that there are no faults with the pre-supply fuel pressure, external leaks or faults with the rail pressure sensor as the HPP will be replaced unnecessarily.

YES

The High-pressure pump is ok

The Volume Control valve (Control flow-regulating valve) **is actuated at idle speed in the next step.**

Setpoint: Engine cuts out due to activation.

The Control flow-regulating valve is the valve at the rear of the HPP see picture page 2. The function of this valve becomes clear, the more that the DDE activates this valve the less fuel that is supplied to the HPP.

Does the engine cut out?

NO

If the engine does not cut out ensure that the DDE is programmed to the latest status as DDE's with function sw lower than V42 will not function as expected at this part of the test. i.e. the engine will not cut out.

Following this if the engine still does not cut out check the wiring and then replace the control flow valve.

YES

The control flow valve operation is ok

The Pressure control valve is then checked in the next steps:

First the pressure control valve is actuated at 20 %
The recorded rail pressure must be between 290 and 470 bar before the test can continue.

Next the duty factor of the pressure control valve is increased in steps.
1600 bar rail pressure must be achieved with a pulse duty factor below 61 %
Typically a good rail pressure system will achieve this target pressure at 45 % actuation.

At the end of this test carry out an inspection of the return lines as a poor connection in this circuit **may leak** at this point in the test. The 1600 bar pressure that is achieved during the module is dumped into the return line at the end of this test.

Functional Description of valve:
The DDE control unit is programmed to actuate this valve at a set duty factor to achieve a set rail pressure, the above test illustrates that the mechanics of the valve are serviceable and that the system can provide maximum pressure.

If the setpoints are not reached and all other previous paths of this test are ok. Ensure that the return pressure is ok then replace this valve.

The test is finished.

2B

Can the engine be started?

NO

In the next step, the rail pressure is checked at start speed.
Note: Ensure that the EWS/DDE interface is released as the DDE control unit will inhibit the build up of rail pressure if there is a fault in this system.

The rail pressure must exceed 250 bar.
Typically on this engine if it is fault free this set point is easily reached. The HPP can produce over 450 bar at cranking speed.

Was the setpoint reached?

YES

If the setpoint was reached then the cause of the engine failing to start must be down to another problem i.e. there is sufficient rail pressure to start the engine.
Diagnosis should now continue with elimination of the DDE voltage supplies and earths, engine speed / position inputs, HFM input and DDE outputs such as injector activations.

NO

Disconnect the rail pressure sensor.
Does the engine start ?

YES

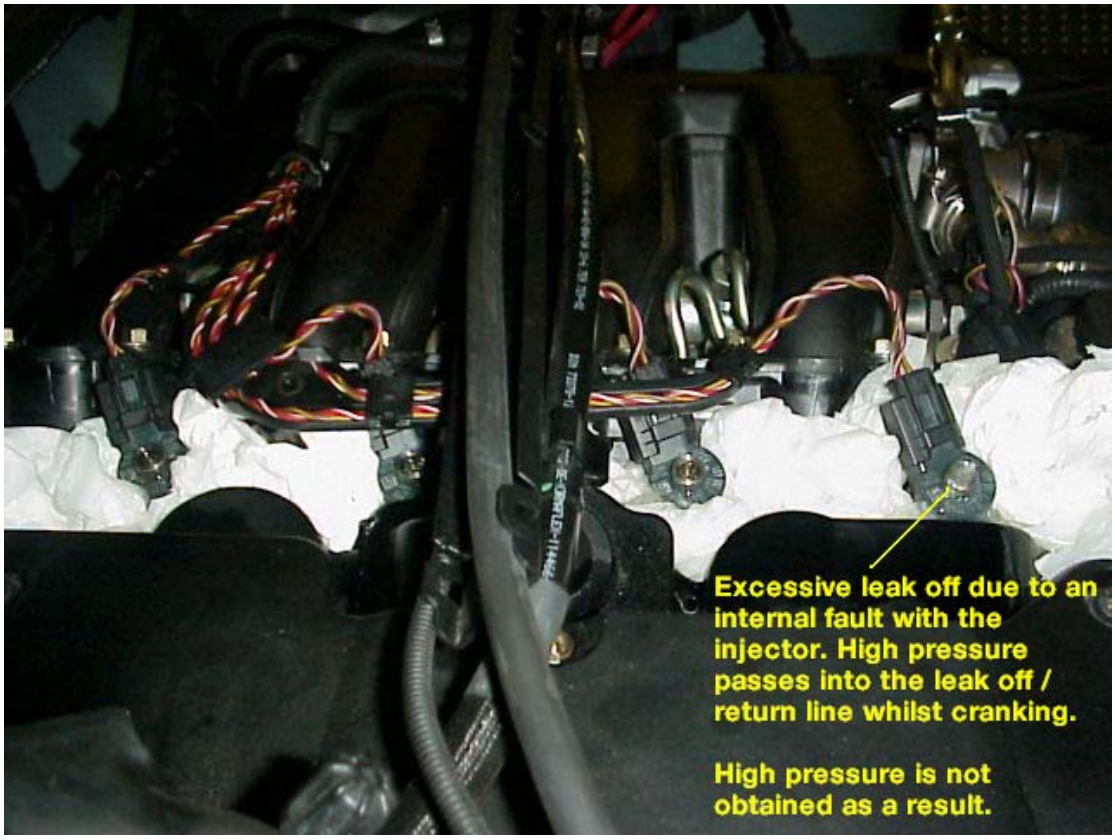
If the engine starts with the rail pressure sensor disconnected this is because the DDE is operating on a substitute value for this sensor. The DDE will not attempt to activate the injectors if the rail pressure is below 250 bar whilst cranking. It will however attempt this when operating on a substitute value for this sensor. Check the wiring for this sensor and pins then replace the sensor.

NO

The following possible causes of fault may be responsible for low rail pressure: (the rail pressure system test is finished at this point)

No pre-supply pressure Check this and the return pressure using the schematic in section 1.
External leak
If the HPP was leaking from the front seal you would find Diesel in the oil sump. Carry out a quick oil level check and check the rest of the system for leaks.
Fuel injector defective (internal leak in fuel return)
Pressure regulator defective (internal leak in fuel return)
Control flow-regulating valve defective (stuck closed)
HPP defective (pressure not generated)

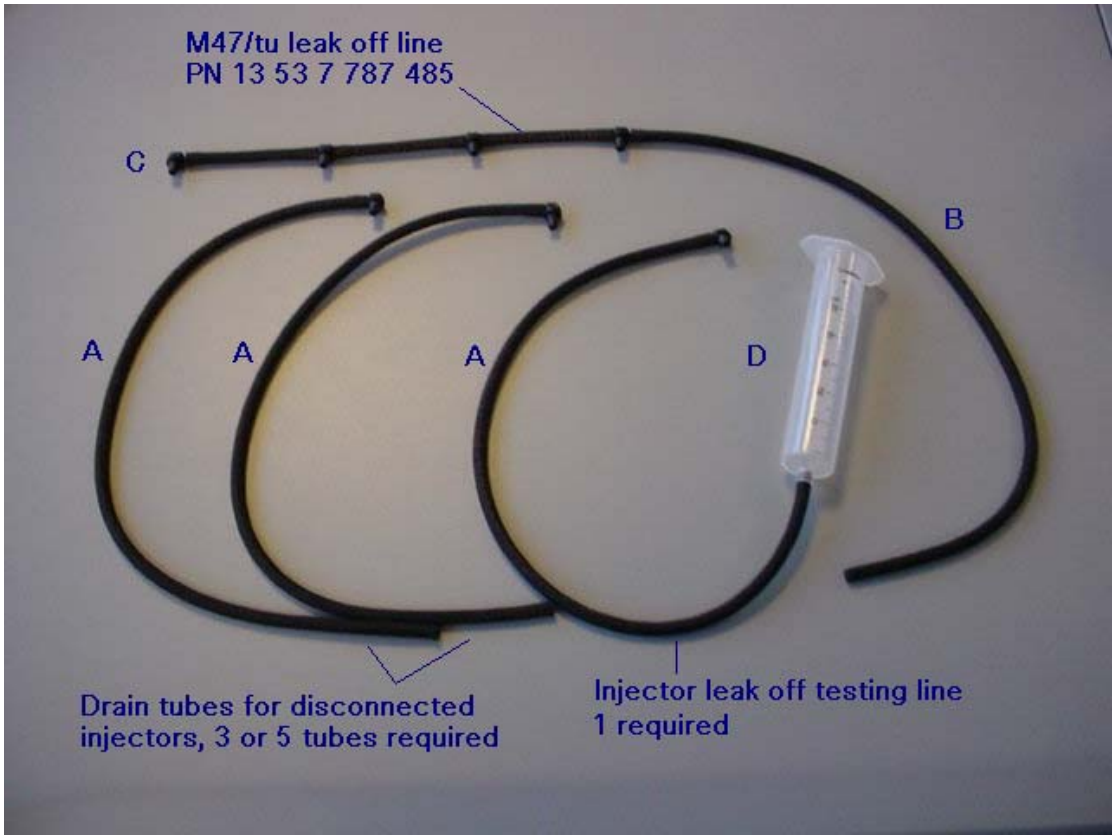
FOLLOW THIS STEP-BY-STEP GUIDE TO DIAGNOSE THE REASON FOR LOW RAIL PRESSURE WHILST CRANKING:



Many thanks to Steven Graham at BMW Heathrow for the above picture.

This can be checked using the following equipment and procedure:

A fault with one injector is enough to drop the rail pressure and prevent the engine from starting!



TO MAKE THE KIT FOR TESTING:

Order 4 or 6 x PN 13 53 7 787 485 (this is the leak off line from the M47/tu engine) **depending on whether you wish to check the "Leak offs" on a 4 or 6 cyl engine, this procedure is the same for both 4 and 6 cyl engines.** (These pipes can be sourced from petrol contamination repairs).
Prepare the kit in the diagram as follows:

1. **Use tube B of 13 53 7 787 485 to make tube A**
2. **Clip on connector C (end L shape piece) from 13 53 7 787 485 to tube A**
3. **Connect an intravenous syringe of approx 60 ml capacity to one of the 4 or 6 testing lines** (available from most chemists)

   The maximum leak off permitted from an injector is 20 cubic centimetres or millilitres whilst cranking per minute.

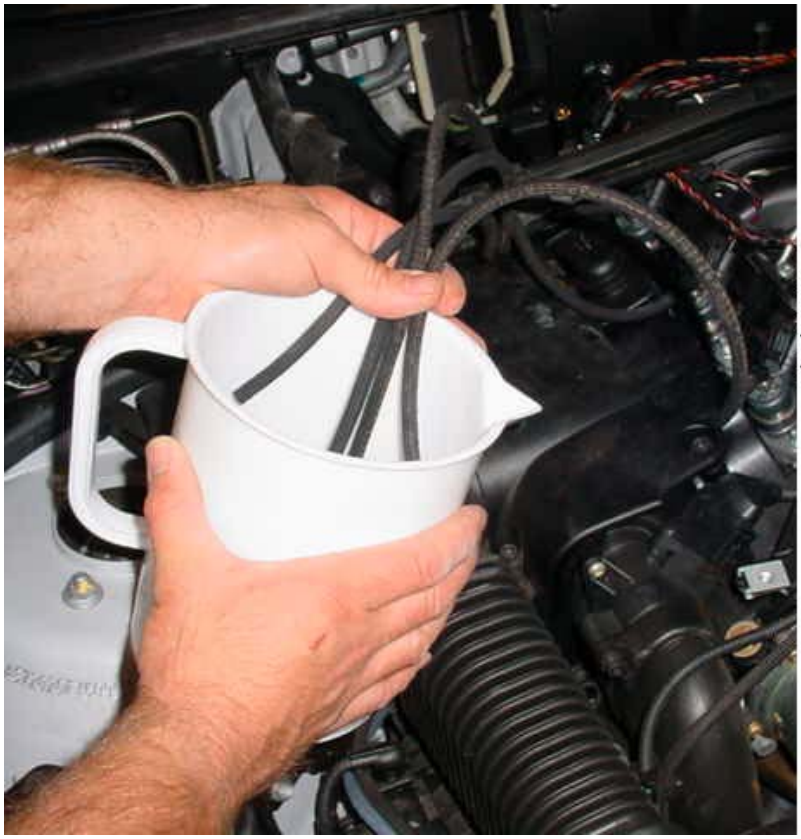
   20 cc / ml per 60 secs whilst cranking
   10 cc / ml per 30 secs whilst cranking
   5 cc / ml per 15 secs whilst cranking

   It is mostly important to check for a high leak off rate from one injector by comparing it to the other injectors on the engine.

   Connect the leak off kit as illustrated below:

Connect the syringe to the injector to be tested and then the other test lines to the remaining injectors.

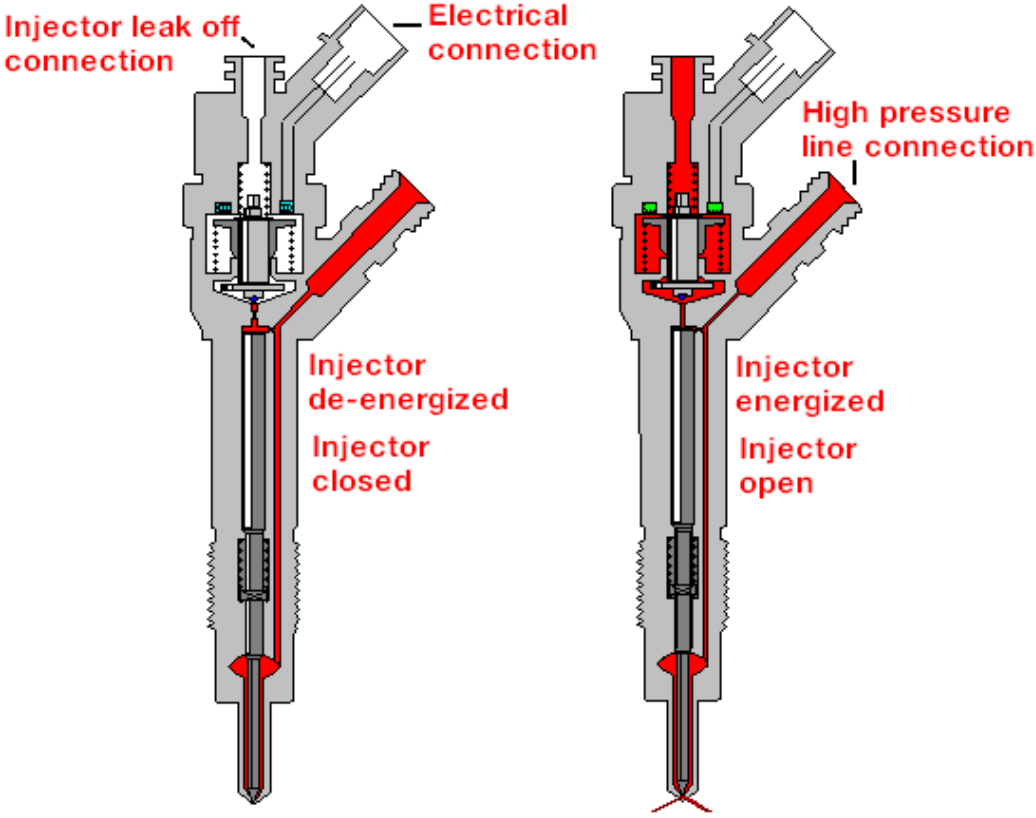
Compare the leak off from each injector to the data above.



Compare the leak off rates from injector to injector to identify a fault with an injector further.

Common rail fuel Injectors, how can they drop the rail pressure via the leak off line?

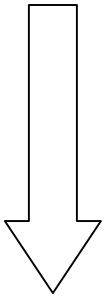
Common rail fuel Injectors, functional description:



When the injector is de-energized high fuel pressure acts upon the needle valve seat and on top of the needle valve.
Once the injector is activated via the DDE the pressure is released on top of the needle valve and the injector valve seat passes fuel into the combustion chamber. Only once the activation from the DDE is stopped does the pressure build above the injector needle and the needle valve seat close, thus finishing 1 injection cycle.

PuMA measure 3012977 states that fuel injectors on the M47/tu and M57/tu from start of series production until 02/2003 may suffer from an internal leak in the injector.

The internal leakage in the injector is caused by a worn sealing element between the high-pressure side and the low-pressure side, which results in the return volume from the injector increasing to an unacceptable level. Consequently, it is not possible to build up the rail pressure required to start the engine.



If you cannot fault any of the injector leak off rates but the rail pressure is still insufficient for engine start then blank off the supply to the injectors using special tool 13 5 413 (this is part of the M57 pressure testing kit 13 5 410) **one at a time to identify whether or not the fuel rail pressure is being lost via a fault with the injector valve seat. Blank off the injector supplies as Illustrated below:**

If the rail pressure is still insufficient for engine start and all the injectors have been blanked off then connect special tool 13 5 450 to test the output from the HPP. The rail pressure sensor and pressure-regulating valve are substituted in this test, the statuses of the rail pressure actual and specified are then checked whilst cranking. This is illustrated in the repair instructions 13 51 542 along with the correct fitment of the tool.

This tool will be auto issued to all dealers by the end of 11/2003.

IMPORTANT:
It is not mentioned in the repair instructions that the air mass meter MUST be disconnected during this test (whilst cranking and checking the pressure readings). This is because the DDE SW has been written so that it is not possible to start the engine if no air is passing through the air mass meter i.e. if there is no signal from the air mass meter.
When checking the pressure reading, the actual pressure whilst cranking should be achieved during the first 3 seconds. The pressure can die off if cranking is continued for a while with the special tool installed as the DDE recognises that the engine has failed to start.

With the special tool installed is the rail pressure sufficient when cranking i.e. >250 bar?
Note:
Typically the HPP on the M47/tu can produce over 450 bar during cranking.

If YES the rail pressure is now ok. The HPP is serviceable and the rail pressure control valve should be replaced.

If NO the rail pressure is still not ok. Then the following components may be responsible:
Control flow-regulating valve defective (stuck closed)
HPP defective (pressure not generated)

At this point check the fuel for contamination carefully as a mechanical defect with the HPP may have introduced swarf into the fuel circuit.

If there is swarf present in the fuel system refer to Technical Bulletin GB 13-001-03.

If the fuel is clean after checking at the fuel filter, HPP connection and in the tank (senders removed) **replace the control flow-regulating valve.**

If the rail pressure is still not ok replace the HPP.

If you are still experiencing problems with the fuel system contact the Technical office via PuMA and detail all work carried out and the values obtained at each test stage.
Photo copy the page below and record your results from each point in the test for your own reference.

Jon Gisborne at the BMW GB Technical office has compiled this guide.

M47/TU data input form:

Has the vehicle run out of fuel at any stage? ……..
If so has the fuel system been bled as per service functions?……
Has the fuel system been bled as per service functions after replacement of parts in the fuel system?……...
Is the fuel system free of swarf?……...
What is the pre-supply pressure?……
What is the return pressure?…….
Has the fuel filter been replaced?…….
Is the fuel system free of leaks?……....
Does the engine oil level appear ok and free from Diesel contamination? …….
What reading was achieved from the rail pressure sensor during the test plan when the ignition is switched on only?……
Is the scope of the HPP ok in reference to the provided illustrations?……
Does the engine cut out during the test when the control flow-regulating valve is operated at maximum activation?…….
What pressure is achieved from the fuel system when the pressure control valve is activated at 20%?…….
What pulse duty factor is required by the DDE to achieve 1600 bar?…….

Notes:

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